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Helium Resources of the United States, 1985

By Richard D. Miller



UNITED STATES DEPARTMENT OF THE INTERIOR

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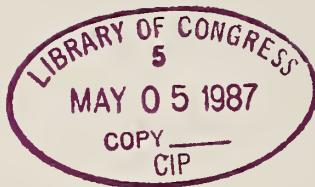
UNITED STATES DEPARTMENT OF THE INTERIOR

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

Bcf	billion cubic feet	psia	pound per square inch, absolute
°F	degree Fahrenheit	Tcf	trillion cubic feet
MMcf	million cubic feet	yr	year

HELIUM RESOURCES OF THE UNITED STATES, 1985

By Richard D. Miller¹

ABSTRACT

The helium resources base of the United States was estimated by the Bureau of Mines to be 1,070 Bcf as of January 1, 1985. These resources are divided into four categories in decreasing degree of assurance of their existence: (1) helium in storage and in proved natural gas reserves, 280 Bcf, (2) helium in probable natural gas resources, estimated at 243 Bcf, (3) helium in possible natural gas resources, estimated to be 287 Bcf, and (4) helium in speculative natural gas resources, which makes up the remaining 260 Bcf.

These helium resources are further divided into depleting, non-depleting, and stored classifications. The depleting resources are those associated with natural gasfields that are, or will be, produced for the natural gas they contain. Almost all of the helium in potential (probable, possible, and speculative) natural gas resources is included in this classification. These depleting resources are estimated to contain 900 Bcf of the total helium resource base. Helium resources contained in nondepleting natural gas resources, those in shut-in, abandoned, or otherwise nonproducing natural gasfields, are estimated to total 133 Bcf. There is 37 Bcf of helium in storage in the Federal Government-owned Cliffside Gas Field near Amarillo, TX.

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INTRODUCTION

The helium resource base of the United States was estimated to be 1,070 Bcf as of January 1, 1985. This includes both identified and undiscovered helium contained in both proved and potential natural gas resources² and helium that was previously separated from natural gas streams and is in storage at Cliffside Gas Field in Bush Dome, Potter County, TX. This publication is the sixth in a series of reports on the helium resources of the Nation. The five previous reports gave information on those resources as of January 1, 1973 (1),³ January 1, 1977 (2), January 1, 1979 (3), January 1, 1981 (4), and January 1, 1983 (5). The Bureau of Mines has been estimating the helium resources of the Nation for over 25 yr in connection with a search for helium occurrences that has been conducted for over 60 yr. These activities are carried on to (1) ensure a continuing supply of helium to fill essential Federal needs, (2) provide information to the Secretary of the Interior so that the helium resources reserved to the United States on Federal land can be properly managed, and (3) provide the public with information on a limited natural resource that is being wasted. The Mineral Leasing Act of 1920 reserves to the United States all helium found on Federal oil and gas leases. The responsibility for ensuring a supply of helium to meet essential Federal needs was assigned to the Secretary of the Interior by the Helium Act of March 3, 1925. The latest legislation on helium is the Helium Act Amendments of 1960.

The estimate of the total helium resource base of 1,070 Bcf compares with 961 Bcf estimated as of January 1, 1983. The primary difference is due to a change in the Potential Gas Committee's (PGC) reporting areas, and the Bureau's estimation helium content averages.

²See appendix for definition of terms.

³Underlined numbers in parentheses refer to items in the list of references preceding the bibliography and appendix at the end of this report.

A significant change in the format of the PGC gas resources reporting areas was made in its latest report on potential resources. The PGC changed its areas from geographic or political boundaries to geologic basin boundaries. There are now 7 reporting areas instead of the 12 used in its December 31, 1982, report. The realignment of reporting areas necessitated changes in the determination of the average helium contents to estimate helium in potential gas resources. The Bureau used geologic basin codes for the first time in the helium resources data base to determine average helium contents for each PGC area.

The helium resources are reported in four categories (table 1): (1) helium in storage and in proved natural gas reserves, (2) helium in probable natural gas resources, (3) helium in possible natural gas resources, and (4) helium in speculative natural gas resources. Helium in storage is the helium stored by the Department of the Interior in Bush Dome at Cliffside Gas Field near Amarillo, TX. Proved natural gas reserves are those estimated by the Department of Energy's (DOE) Energy Information Administration and those in nondepleting fields not included in the DOE estimate. The potential natural gas resources (probable, possible, and speculative) are those estimated to exist by the PGC. Additionally, 20 Bcf of helium is estimated to exist in nondepleting probable

TABLE 1. - Helium resources of the United States as of January 1, 1985

(14.73 psia and 60° F)

Helium resource category	Natural gas resource category	Helium, Bcf
Identified:		
Measured ¹	Proved.....	280
Indicated....	Probable.....	243
Undiscovered:		
Hypothetical.	Possible.....	287
Speculative..	Speculative.....	260
Total.....	NAp.....	1,070

NAp Not applicable.

¹Includes helium in storage.

resources not included in the PGC estimates.

Helium in proved and probable natural gas resources is sometimes reported in terms of helium content ranges. These ranges are 0.3% or more, 0.1% to 0.29%, and less than 0.1%. There has been some effort to evaluate individual gasfields containing natural gas with helium contents less than 0.1%; however, this effort has been limited to fields in only four States: Colorado, Montana, Utah, and Wyoming. The helium content ranges have no particular significance, but in general, the higher the percentage of helium, the more likely it is that the

helium could be economically extracted. In earlier years, gas containing at least 0.3% helium (helium-rich gas) was the only gas of concern to the helium evaluation program. Now, because of the wider scope of the present helium resource survey and because gases containing less than 0.3% helium can be economically processed, natural gases with less than 0.3% helium are included in the evaluation program. Helium recovery cost is affected by many variables besides the helium content of the natural gas. These include average daily rate of gas processed, hydrocarbon recovery, life of reserves, and total helium reserves.

HELIUM RESOURCES

Helium occurs as a constituent of natural gas, which is presently the only economical source, although helium is also present in much smaller concentrations in the atmosphere. For the purposes of this report, only those helium resources found in natural gas or previously separated from natural gas and now in storage are considered as a part of the Bureau's helium resources base. The natural gas in which helium is found may be normal fuel gas or naturally occurring gas of low heating value.

Helium contents of the natural gas resources were derived from Bureau records of helium analyses of natural gas samples, which are part of the Bureau resources data base. The analyses of natural gas and limited evaluations of helium resources were begun in 1917. Almost 18,000 natural gas samples from wells and pipelines in the United States have been analyzed. Through 1984, 13,957 of these analyses had been published in 32 Bureau publications, which are listed in the bibliography of this report.

HELIUM IN STORAGE

In 1961, the Government contracted to purchase helium from five extraction plants built by four private companies adjacent to large natural gas transmission pipelines. The gas, principally from the West Panhandle and Hugoton Gasfields in the Oklahoma and Texas

Panhandles and in southwest Kansas, was being produced for fuel, and as the gas was burned, the helium was released to the atmosphere and wasted. Using private funds, these companies constructed plants to extract crude helium for sale to the Government. The helium was delivered into a Government-owned pipeline that connected all plants with the Bush Dome at Cliffside Gas Field near Amarillo, TX. Further information concerning the Government's helium purchases can be found in the first report of this series (1).

As of January 1, 1985, the helium stored in Bush Dome totaled 37.2 Bcf. This total comprises 34.5 Bcf that was accepted by the Government from the conservation plants under contract or was produced by Government-owned helium extraction plants and was excess to Federal market demands. The other 2.7 Bcf is stored by the Government for private companies under separate contracts.

Bush Dome was the source of helium-bearing natural gas that was processed for helium extraction at the Government's Amarillo Helium Plant from 1929 until the plant ceased helium extraction operations in April 1970. About 99 Bcf of the natural gas has been produced from the field, but there is about 209 Bcf of recoverable reserves remaining. The natural gas averages about 1.86% contained helium; therefore, remaining native helium reserves amount to 3.9 Bcf. Since the closing of the Amarillo Helium Plant,

natural gas has been produced from this field to facilitate storage and the Government's Exell Helium Plant operations north of Amarillo, TX. Helium contained in the remaining native gas is included with the helium in proved natural gas reserves.

**HELUM IN PROVED RESERVES
OF NATURAL GAS**

Helium in proved reserves of natural gas as of January 1, 1985, totals 243 Bcf. This is divided by helium content into three groups: 0.3% or more, 0.1% to 0.29%, and 0% to 0.09%. Helium in proved reserves of natural gas is divided into a fourth group of 0.05% to 0.09% in four states: Colorado, Montana, Utah, and Wyoming; however, the helium resources in this category are grouped with the 0% to 0.09%. Presently, no helium is being extracted from gas streams with less than 0.3% helium. Known fields containing at least 0.3% helium and fields in the 0.1% to 0.29% helium range have been identified and evaluated in the helium resources evaluation program. As of January 1, 1985, fields containing natural gas with helium contents less than 0.1% have not been separated and individually evaluated, except in the aforementioned four states. Therefore, these helium resources are determined by use of average helium content values and DOE reported reserves.

Natural Gas Containing
0.3% or More Helium

As of January 1, 1985, it was estimated that there was 197.9 Bcf of helium contained in proved natural gas reserves having at least 0.3% helium. These reserves were located in 95 fields in 11 States. The reserves by State are shown in table 2.

Since 1950, the Bureau has been making estimates of the helium resources of the Nation, although for several years the estimates included only the fields that contained major deposits of helium and at least 0.3% helium. These fields were the Hugoton in southwest Kansas and the Oklahoma and Texas Panhandles, West

TABLE 2. - Helium reserves in proved natural gas reserves containing 0.3% or more helium, by State

(14.73 psia and 60° F)

<u>State</u>	<u>Helium, MMcf</u>
Alaska.....	70
Arizona.....	2,531
Colorado.....	1,948
Kansas.....	51,667
Montana.....	1,434
New Mexico.....	4,852
Oklahoma.....	7,531
Texas.....	19,917
Utah.....	3,618
West Virginia.....	113
Wyoming.....	104,217
Total.....	197,898

Panhandle in Texas, Greenwood in Kansas, Keyes in Oklahoma, and Cliffside in Texas. Even today these fields are estimated to contain about 37% or 73 Bcf of the helium in gas with at least 0.3% helium. The natural gas from all these fields is being produced for fuel, and the helium that is not extracted is lost as the natural gas is burned. Bush Dome in Cliffside Field is being produced only for the Federal Government's helium program needs and for redelivery of helium stored under contract.

As the helium resources evaluation program progressed through the years, more comprehensive data were collected and the estimates were improved. In 1961, a major improvement in the program took place when, for the first time, helium reserves were estimated for all fields from which samples containing more than 0.3% helium had been analyzed in connection with the gas sampling program. Available data for many of these smaller fields were limited for the first evaluation efforts, but over the intervening years, data have been collected from all known available sources, and this has resulted in a comprehensive assessment of the total helium reserves of the country. The measured helium reserve estimates for each year beginning in 1950 appear in table 3, which also compares the trend of helium reserves of the United States with

TABLE 3. - Helium reserves in proved natural gas reserves containing 0.3% or more helium, by year

(Million cubic feet at 14.73 psia and 60° F)

Year	Helium contained in natural gas having at least 0.3% helium	Helium in storage	AGA and DOE estimates of natural gas reserves ¹
1950.....	248,642	82	179,401,693
1951.....	242,675	81	184,584,745
1952.....	242,675	86	192,758,910
1953.....	235,713	87	198,631,566
1954.....	229,745	86	210,298,763
1955.....	222,783	86	210,560,931
1956.....	216,816	70	222,482,544
1957.....	210,849	46	236,483,215
1958.....	203,887	24	245,230,137
1959.....	197,919	17	252,761,792
1960.....	192,946	106	261,170,431
1961.....	194,373	268	262,326,326
1962.....	194,373	438	266,273,642
1963.....	191,311	509	272,278,858
1964.....	187,855	2,042	276,151,233
1965.....	177,886	5,317	281,251,454
1966.....	169,695	8,870	286,468,923
1967.....	163,589	12,407	289,332,805
1968.....	155,076	16,138	292,907,703
1969.....	148,408	19,863	287,349,852
1970.....	140,386	23,693	275,108,835
1971.....	135,850	27,573	290,746,408
1972.....	127,873	31,491	278,805,618
1973.....	119,515	34,903	266,084,846
1974.....	113,470	37,426	249,950,207
1975.....	108,358	37,501	237,132,497
1976.....	101,152	37,760	228,200,176
1977.....	96,745	38,261	216,026,074
1978.....	89,783	38,651	208,877,878
1979.....	83,991	39,055	200,301,707
1980.....	82,293	39,399	194,916,624
1981.....	² 120,114	39,583	199,021,000
1982.....	128,504	39,424	201,730,000
1983.....	² 182,537	38,448	201,512,000
1984.....	198,565	37,687	200,247,000
1985.....	197,898	37,237	197,463,000

¹AGA and DOE reserve estimates are given as of December 31 of previous year.

²Increase due primarily to an increase in helium reserves in southwest Wyoming.

the natural gas reserves as estimated by the American Gas Association (AGA) through 1979 and DOE for 1980-84. This is shown graphically in figure 1.

Before the implementation of crude helium purchases in late 1962, all of the previously mentioned gasfields with large

helium reserves were being produced for fuel. The resultant loss of helium amounted to about 8 Bcf per year. Under the crude helium purchase program, about 3.5 Bcf of the helium that would otherwise have been wasted was saved annually from 1963 through November 12, 1973, when

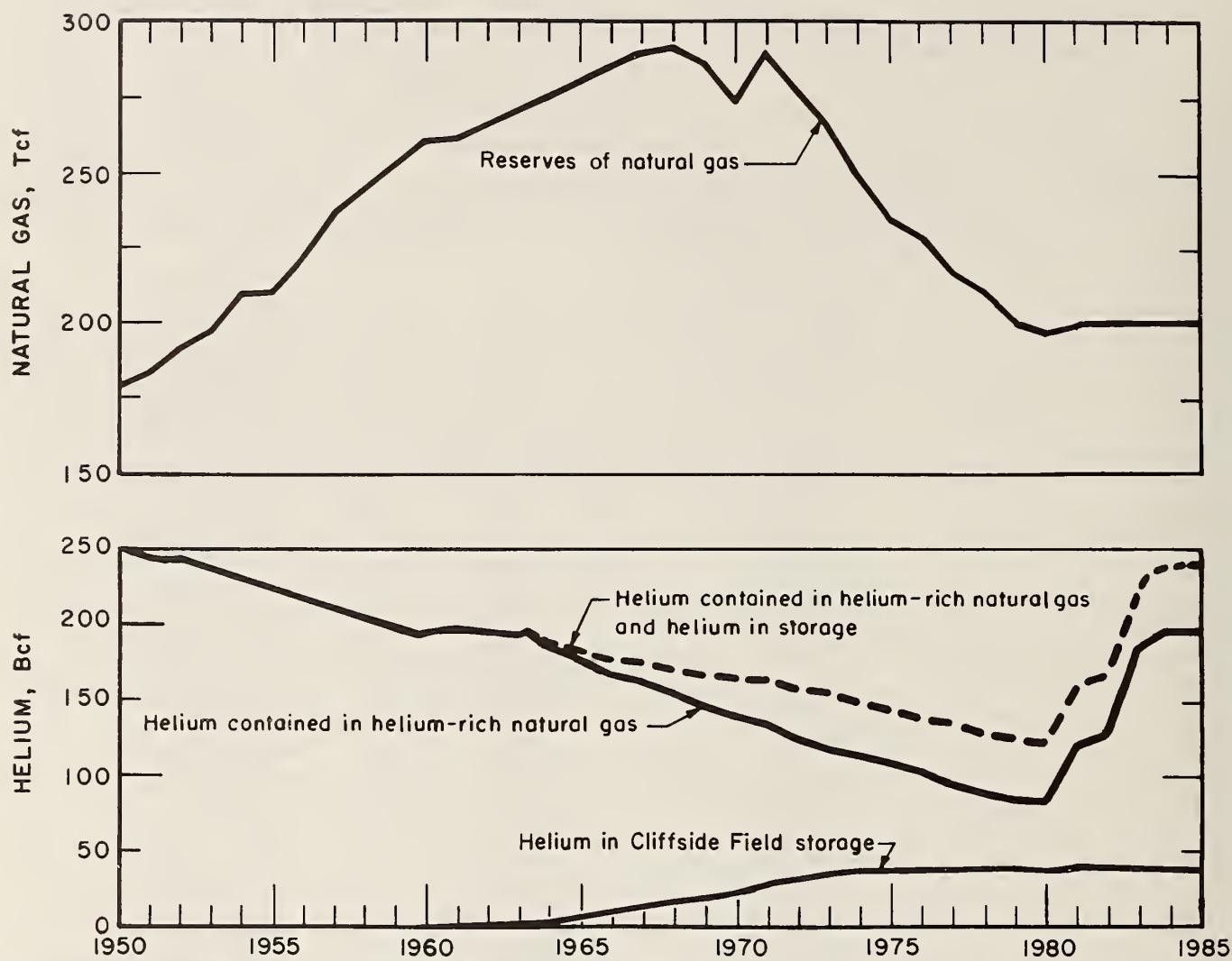


FIGURE 1.—AGA and DOE reserves of natural gas (top), helium in natural gas containing 0.3% or more helium (bottom), and helium in storage (bottom).

acceptance of helium from the private conservation plants ceased. In 1984, about 749 Bcf of natural gas with a helium content of at least 0.3% was produced, which contained 3.9 Bcf of helium. About 1.2 Bcf of this helium was extracted by private plants and either used or stored in Bush Dome at Cliffside Field. The remainder, about 2.7 Bcf of helium, was lost to the atmosphere as the gas was used for fuel.

There are gasfields that contain gas with at least 0.3% helium that are not being produced, and consequently, the helium is not being wasted. These are classified as nondepleting helium reserves. There are 41 fields in 7 States containing gas in this category, with measured helium reserves estimated to be

112.5 Bcf. There are various reasons why these fields are not being produced. Some are located in remote areas where pipeline connections are not presently available; in other cases, the gas is being used in pressure maintenance operations to produce associated oil. In the majority of these fields, however, the helium is in natural gas that has low heating value and thus is not suitable for fuel. Fields in the first two groups will be put on production eventually, and the helium reserves will then be removed from the nondepleting category. As natural gas prices rise, some of the fields in the third group, those that were non-commercial at the time of discovery, will become profitable and then be produced.

About 103.7 Bcf of the nondepleting measured helium reserves is contained in natural gas located on Federal lands. The Government retains title to all helium on these Federal lands even though the oil and gas rights may be leased to private companies or individuals. These nondepleting reserves on Federal lands may serve as a backup to the helium stored by the Government and are an integral part of the Government's helium conservation efforts.

Natural Gas Containing
0.1% to 0.29% Helium

The helium resources evaluation program was expanded in 1974 to include individual gasfields that produced gas with at least 0.1% helium but less than 0.3% helium. Some reasons for evaluating gas reserves with lower helium contents were the improved technology and economics of extraction operations made possible by multipurpose plants, making it feasible to process gas with lower helium contents. The evaluation of these fields was done on an area-by-area basis. The entire United States was evaluated at the end of 1982. Helium resources in the 0.1% to 0.3% category as of January 1, 1985, are shown in table 4.

All other gas-producing states containing gas with helium contents of 0.1% to 0.29% have been evaluated and found to contain no significant helium.

Natural Gas Containing
Less Than 0.1% Helium

In 1984, the first helium resources report was completed, which showed individual field evaluations of helium resources in natural gas containing less than 0.1% helium. By January 1, 1985, two reports had been completed that showed evaluation of helium in natural gas with 0.05% to 0.09% helium content. Fields containing natural gas with a helium content between 0.05% to 0.09% were individually evaluated in Colorado, Montana, Utah, and Wyoming. However, only fields in Colorado and Montana had sufficient natural gas reserves to be considered for addition to the helium

TABLE 4. - Helium resources in proved natural gas reserves with helium contents of 0.1% to 0.29%, by State

(14.73 psia and 60° F)

<u>State</u>	<u>Helium, MMcf</u>
Arkansas.....	479
Colorado.....	24
Kansas.....	646
Montana.....	508
Oklahoma.....	737
Texas.....	1,343
Wyoming.....	678
Total.....	4,415

sources in this category. As of January 1, 1985, helium resources in natural gas with a helium content from 0.05% to 0.09% is 7,630 MMcf in Colorado and 198 MMcf in Montana. All other helium resources were determined by using DOE natural gas reserves estimates and the Bureau's helium analysis files.

The DOE has made annual estimates of the natural gas reserves of the United States since 1977.⁴ DOE estimates for 1984 were used to estimate the volume of helium in the proved reserves of gas having less than 0.01% helium. The DOE estimate of proved natural gas reserves as of December 31, 1984 (6), was 197,463 Bcf. The estimate was made by combining estimates for several geographic divisions within the United States. Table 5 shows the gas reserve estimate for each geographical area, as published by the DOE.

The average helium contents for gases having less than 0.1% helium in each DOE reporting area are also shown in table 5. The helium content fractions were derived from the gas analysis data in the Bureau's helium analysis files. These values were then applied to the estimated natural gas reserves to determine the volume of helium contained in gases with less than 0.1% helium. For those areas

⁴From 1945-1979, the AGA made annual estimates of the natural gas reserves of the United States. The AGA ceased making these estimates after 1979.

TABLE 5. - DOE estimates of proved natural gas reserves as of December 31, 1984, with applicable helium content fraction and helium in gas having less than 0.1% helium
 (Volumes in billion cubic feet at 14.73 psia and 60° F)

Area	Natural gas reserves	Helium content fraction	Helium contained in natural gas having less than 0.1% helium
Alabama.....	785	0.00050	0.39
Alaska.....	34,283	.00014	14.80
Arkansas.....	2,069	.00060	11.05
California.....	5,781	.00003	.17
Colorado.....	3,148	.00073	1,28.12
Florida.....	49	.00015	.01
Kansas.....	9,553	.00060	1.00
Kentucky.....	554	.00051	.28
Louisiana:			
North.....	2,939	.00031	.91
South.....	39,622	.00004	1.58
Michigan.....	1,219	.00033	.40
Mississippi.....	1,596	.00037	.59
Montana.....	896	.00066	1,2.24
New Mexico:			
East.....	3,230	.00032	1.98
West.....	8,446	.00018	11.50
New York.....	295	.00026	.08
North Dakota.....	600	.00032	.19
Ohio.....	2,030	.00051	1.04
Oklahoma.....	16,211	.00045	16.35
Pennsylvania.....	1,882	.00045	.85
Texas:			
Offshore.....	7,562	.00004	.30
District 1.....	1,087	.00019	.21
District 2.....	2,534	.00004	.10
District 3.....	4,680	.00004	.19
District 4.....	8,316	.00004	.33
District 5.....	1,448	.00017	.25
District 6.....	4,857	.00023	1.12
District 7B....	1,027	.00042	1.20
District 7C....	2,568	.00048	1.23
District 8....	8,156	.00025	2.04
District 8A....	966	.00043	.42
District 9....	932	.00055	.51
District 10....	5,919	.00044	1.10
Utah.....	2,333	.00017	1.38
Virginia.....	175	.00028	.05
West Virginia....	2,194	.00055	11.19
Wyoming.....	10,227	.00014	1.41
Miscellaneous ³ ...	75	NA	NA
Total.....	197,463	NAP	240.56

NA Not available. NAP Not applicable.

¹Natural gas reserves containing gases with helium contents of at least 0.1% were subtracted from total natural gas reserves to determine contained helium.

²Includes evaluated helium resources in natural gas with a helium content of 0.05% to 0.09%.

³Includes reserves of Arizona, Illinois, Indiana, Maryland, Nebraska, Oregon, South Dakota, and Tennessee.

also having gas with 0.1% or more helium, the volume of gas with 0.1% or more helium was subtracted from the total DOE reported volume before the helium content fraction was applied. For Colorado, Montana, Utah, and Wyoming natural gas reserves, helium contents and helium resources were adjusted to reflect the evaluation of helium resources in natural gas with a helium content of 0.05% to 0.09%. The helium resources in measured gases with a helium content of less than 0.01% are estimated to be 40.56 Bcf.

HELUM IN POTENTIAL RESOURCES OF NATURAL GAS

The PGC has estimated that there was 784 Tcf of natural gas in the Nation's potential natural gas resource base, as of December 31, 1984 (7).

The PGC, which reports on the potential gas supply of the Nation, is sponsored by the Potential Gas Agency, Mineral Resources Institute, Colorado School of Mines. It is made up of representatives

from the oil and gas producing industry, gas transmission industry, Government, and academic community. The committee made its initial report on future natural gas supply in 1967, although a predecessor committee, the Future Gas Supply Committee, produced a report on the same subject in 1964. The PGC incorporated a major change in its December 31, 1984, report. The PGC is now reporting potential natural gas resources by areas with geologic basin boundaries rather than geographic or political boundaries. The committee reduced the areas from 12 to 7. The seven PGC reporting areas are shown in figure 2.

The potential resources of natural gas are broken down by the PGC into three categories: probable, possible, and speculative. These are listed in the order of decreasing likelihood of existence; the probable category is associated with known fields, the possible category includes undiscovered fields in productive areas, and the speculative category covers resources to be



FIGURE 2.—PGC area map.

found in presently unexplored areas. The PGC defines these terms more specifically as follows:

1. Probable potential gas supply is associated with existing fields. It is the most assured of potential supplies because it is associated with known accumulations, and a relatively large amount of geological and engineering information is available to aid in estimation of the reported figures in this category. The probable supply bridges the boundary between discovered and undiscovered resources. The discovered portion includes supply from future extensions of existing pools in known productive reservoirs. The pool containing this gas has been discovered, but the extent of the pool has not been completely delineated by development drilling; therefore, the existence and quantity of gas in the un-drilled portion of the pool are as yet unconfirmed. The undiscovered portion of probable supply is expected to come from future new pool discoveries within existing fields, either in reservoirs productive elsewhere in the field or in shallower or deeper formations known to be productive elsewhere in the same geologic province or subprovince.

2. Possible potential gas supply is a less assured supply because it is postulated to exist outside of known fields, but it is associated with a productive formation in a productive province. Its occurrence is indicated by projection of plays or trends of a producing formation into a less well explored area of the same geologic province or subprovince. Supply is from new field discoveries postulated to occur within these trends or plays under both similar and different geologic conditions; i.e., the types of traps and/or structural settings may either be the same or differ in some aspect.

3. Speculative potential gas supply is the most nebulous category. This potential supply is from formations or provinces that have not yet proven to be productive. Geologic analogs are developed in order to ensure reasonable evaluation of these unknown quantities. Supply is from new pool or new field discoveries in formations not previously productive

within a productive geologic province or subprovince and also new field discoveries within a geologic province not previously productive.

In comparing the PGC definitions with the terminology adopted by the Bureau and the U.S. Geological Survey, it appears that the PGC "probable" category is closely related to the Federal "indicated" category. This would then bring the "probable" resources into the "identified" range, as shown in table 1. This is an apparent contradiction to the PGC's treatment of that class of reserves; however, it seems to be the best placement. A Geological Survey report discusses the PGC estimates (8, p. 19), stating that the "probable category includes, however, some known resources, in the sense of having been discovered but not completely developed, and some unknown resources, so that the category brackets the boundary between the known and the unknown." For this report and the previous Bureau studies, the PGC "probable" category is compared with the "indicated" category under "identified" resources, and PGC's "possible" and "speculative" are compared with the "hypothetical" and "speculative" categories under "undiscovered" resources in Bureau terminology.

The helium contained in potential gas resources was estimated by using the average helium content of each PGC area. The average helium contents were determined for each PGC area by using helium contents of basins coded in the helium resources data base. The helium resources data basin codes were correlated with the PGC basin codes to derive the average helium content of each area. These helium contents range from 0.003% to 0.253%.

Helium contained in the potential gas resources was estimated to be 770 Bcf. In addition to this, the Bureau estimates that there is 20 Bcf of helium in probable resources of known fields containing nondepleting gas. The total helium resources then, in the indicated, hypothetical, and speculative categories is 790 Bcf.

Table 6 shows the estimates of the natural gas resources for all areas of the continental United States and Alaska

TABLE 6. - PGC estimate of potential supply of natural gas in the United States as of December 31, 1984, by area

(Volumes in trillion cubic feet at 14.73 psia and 60° F)

Area	Probable	Possible	Speculative	Total
Alaska.....	9.1	29.1	99.2	137.4
Atlantic.....	24.3	8.8	51.1	84.2
Gulf Coast.....	54.8	96.0	38.2	189.0
Mid-Continent.....	46.3	88.2	58.4	192.9
North Central.....	.1	2.3	10.3	12.7
Pacific.....	1.9	15.6	15.7	33.2
Rocky Mountain.....	48.3	53.0	33.4	134.7
Total.....	184.8	293.0	306.3	784.1

TABLE 7. - Estimated helium in potential supplies of natural gas as of January 1, 1985, by PGC area

(Volumes in billion cubic feet at 14.73 psia and 60° F)

Areas	Helium content, %	Indicated helium in probable resources	Hypothetical helium in possible resources	Speculative helium in speculative resources	Total helium
Alaska.....	0.014	1.27	4.07	13.89	19.23
Atlantic.....	.116	28.19	10.21	59.28	97.68
Gulf Coast.....	.006	3.29	5.76	2.29	11.34
Mid-Continent.....	.146	67.59	128.77	85.26	281.62
North Central.....	.142	.14	3.27	14.63	18.04
Pacific.....	.003	.06	.47	.47	1.00
Rocky Mountain.....	.253	142.34	134.09	84.50	360.93
Total..	NAp	242.88	286.64	260.32	789.84

NAp Not applicable. ¹Includes 20.14 Bcf of helium in nondepleting resources.

in the various categories designated by the PGC. Table 7 shows the volume of helium estimated to be contained in the natural gas resources shown in table 6.

It is assumed that the helium content of the gas discovered in the future will be the same as that in past discoveries in all PGC areas.

DISSIPATION OF HELIUM RESOURCES

Estimates of future gas production of proved and potential resources for this report were based on extrapolations of gas supply estimates by the AGA (9). The AGA categorizes potential supply as follows: lower 48 States, synthetic gas, Alaskan, imports, and nonconventional. For this study, the natural gas supply estimates for the lower 48 States and Alaska were used. The AGA bases its high-case Alaskan supply estimates on the proposed 1990 completion of the Alaskan Highway Project to carry gas by pipeline to the lower 48 States. However, this

project depends on the demonstrated need for Alaskan gas in the lower 48 States. For this study, 1995 was considered the starting date for natural gas to be transported through the Alaskan Highway Project pipeline.

The AGA gas supply estimates for the lower 48 States for 1990 ranged from a low of 17.5 Tcf to a high of 22.0 Tcf. The AGA year 2010 supply estimates ranged from 11.2 to 22.5 Tcf for the lower 48 States and from 0.8 to 2.0 Tcf for Alaskan gas. Actual production from the lower 48 States for 1984 was 16.9 Tcf.

Production from Alaska amounted to approximately 0.3 Tcf in 1984.

To forecast available helium in natural gas produced for market, the average helium content for each area was applied to those forecasted gas production rates. Since the AGA forecasts were made only through the year 2010, it was necessary to extend them through 2020 for the purposes of this report. The extension was based on past production (fig. 3), the AGA forecast through 2010, the volume of proved reserves, and the undiscovered gas resources estimated by the PGC. The forecasted natural gas volumes and the helium expected to be produced with the gas are shown in table 8 and figure 4.

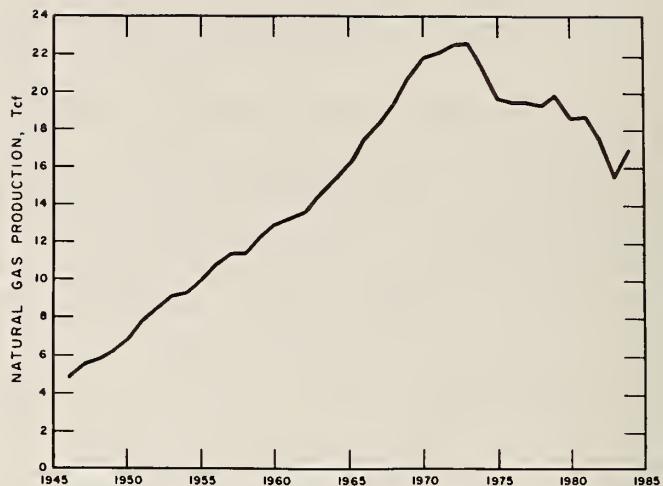


FIGURE 3.—Annual gas production estimates for 1945-79 (AGA) and 1980-84 (DOE).

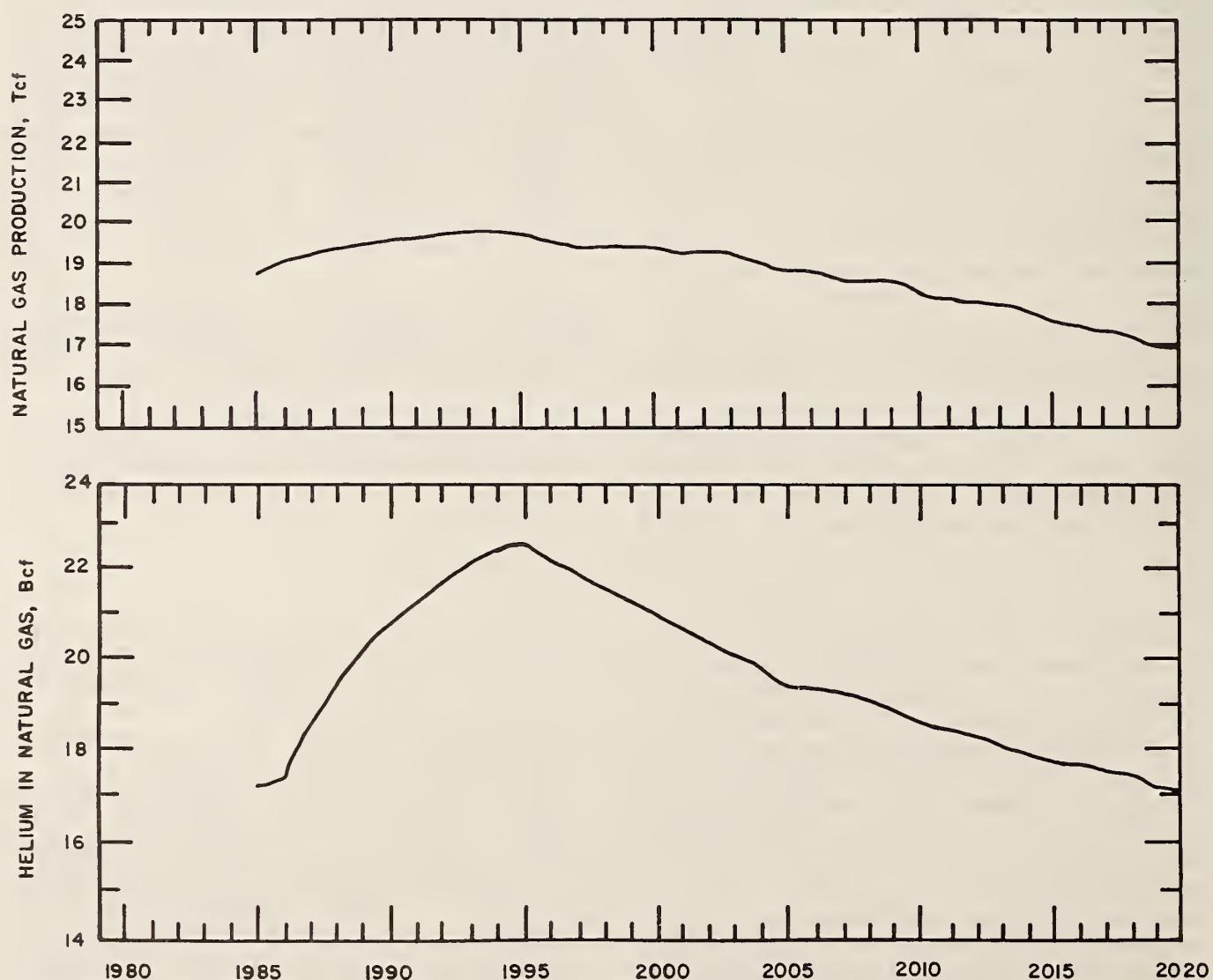


FIGURE 4.—Projected natural gas production (top) and projected helium in natural gas production (bottom) in the United States.

TABLE 8. - Projected natural gas and helium production in the United States
(Billion cubic feet at 14.73 psia and 60° F)

Year	Natural gas production	Contained helium	Year	Natural gas production	Contained helium
1985.....	18,722	17.065	2003.....	19,106	19.909
1986.....	18,921	17.283	2004.....	18,977	19.641
1987.....	19,120	18.434	2005.....	18,848	19.391
1988.....	19,220	19.293	2006.....	18,818	19.252
1989.....	19,419	20.144	2007.....	18,689	19.119
1990.....	19,518	20.769	2008.....	18,559	19.033
1991.....	19,617	21.328	2009.....	18,529	18.898
1992.....	19,518	21.537	2010.....	18,301	18.532
1993.....	19,717	22.087	2011.....	18,171	18.291
1994.....	19,717	22.354	2012.....	18,142	18.275
1995.....	19,717	22.456	2013.....	17,903	18.050
1996.....	19,434	21.798	2014.....	17,803	17.864
1997.....	19,375	21.413	2015.....	17,604	17.653
1998.....	19,415	21.191	2016.....	17,505	17.641
1999.....	19,355	20.853	2017.....	17,306	17.395
2000.....	19,395	20.654	2018.....	17,300	17.373
2001.....	19,167	20.256	2019.....	17,008	17.090
2002.....	19,236	20.182	2020.....	16,908	17.042

CONCLUDING STATEMENT

In previous Bureau reports on helium resources, it was concluded that relatively large volumes of helium would be available from natural gas through the year 2020, although that helium would probably be in gases with leaner concentrations than those being processed for helium today. There have been no developments in the past 2 yr to alter these conclusions. Because of the expected leaner concentrations of helium in natural gas, extraction plants will have to process larger quantities of gas to recover equivalent volumes of helium. This will probably require that the extraction plants be located on gas transmission

systems that bring large volumes of natural gas together at one point.

As of January 1, 1985, there was 37.2 Bcf of helium in storage in Bush Dome at Cliffside Gas Field. The Bureau owns 34.5 Bcf, and 2.7 Bcf is owned by private companies and is stored under separate storage contracts. There is also about 3.9 Bcf of helium contained in the native gas in Bush Dome, which is owned by the Federal Government. This reserve of helium, and the helium on Federal lands in presently nondepleting fields, will fill the Bureau's mission of supplying helium to meet all essential Government needs for many years beyond 2000.

REFERENCES

1. Moore, B. J. Helium Resources of the United States, 1973. BuMines IC 8708, 1976, 17 pp.
2. _____. Helium Resources of the United States, 1977. BuMines IC 8803, 1979, 25 pp.
3. _____. Helium Resources of the United States, 1979. BuMines IC 8831, 1980, 27 pp.
4. Hertweck, F. R., Jr., and R. D. Miller. Helium Resources of the United States, 1981. BuMines IC 8927, 1983, 17 pp.
5. Miller, R. D. Helium Resources of the United States, 1983. BuMines IC 9028, 1985, 17 pp.
6. Department of Energy, Energy Information Administration. U.S. Crude oil,

Natural Gas, and Natural Gas Liquids Reserves. 1984 Annual Report. DOE/EIA-0216(84) Sept. 25, 1985, 98 pp.

7. Potential Gas Committee. Potential Supply of Natural Gas in the United States (as of December 31, 1984). Potential Gas Agency. CO School Mines, Golden, CO, 1985, 161 pp.

8. Theobald, P. K., S. P. Schweinfurth, and D. C. Duncan. Energy Resources of the United States. U.S. Geol. Surv. Circ. 650, 1972, 27 pp.

9. American Gas Association. The Gas Energy Supply Outlook Through 2010. AGA Gas Supply Comm., Arlington, VA, Oct. 1985, 62 pp.

BIBLIOGRAPHY

Anderson, C. C., and H. H. Hinson. Helium-Bearing Natural Gases of the United States. Analyses and Analytical Methods. BuMines 486, 1951, 141 pp.

Boone, W. J., Jr. Helium-Bearing Natural Gases of the United States. Analyses and Analytical Methods. Supplement to Bulletin 486. BuMines 576, 1958, 117 pp.

Munnerlyn, R. D., and R. D. Miller. Helium-Bearing Natural Gases of the United States: Analyses. Second Supplement to Bulletin 486. BuMines 617, 1963, 93 pp.

Miller, R. D., and G. P. Norrell. Analyses of Natural Gases of the United States, 1961. BuMines IC 8221, 1964, 148 pp.

_____. Analyses of Natural Gases of the United States, 1962. BuMines IC 8239, 1964, 120 pp.

_____. Analyses of Natural Gases of the United States, 1963. BuMines IC 8241, 1965, 102 pp.

Moore, B. J., R. D. Miller, and R. D. Shrewsbury. Analyses of Natural Gases of the United States, 1964. BuMines IC 8302, 1966, 144 pp.

_____. Analyses of Natural Gases of the United States, 1965. BuMines IC 8316, 1966, 181 pp.

_____. Analyses of Natural Gases, 1966. BuMines IC 8356, 1967, 130 pp.

Moore, B. J., R. D. Miller, and R. D. Shrewsbury. Analyses of Natural Gases, 1967. BuMines IC 8395, 1968, 187 pp.

Cardwell, L. E., and L. F. Benton. Analyses of Natural Gases, 1968. BuMines IC 8443, 1970, 169 pp.

_____. Analyses of Natural Gases, 1969. BuMines IC 8475, 1970, 134 pp.

_____. Analyses of Natural Gases, 1970. BuMines IC 8518, 1971, 130 pp.

_____. Analyses of Natural Gases, 1971. BuMines IC 8554, 1972, 163 pp.

_____. Analyses of Natural Gases, 1972. BuMines IC 8607, 1973, 104 pp.

Moore, B. J. Analyses of Natural Gases, 1973. BuMines IC 8658, 1974, 96 pp.

_____. Analyses of Natural Gases, 1974. BuMines IC 8684, 1975, 122 pp.

_____. Helium Resources of the United States, 1973. BuMines IC 8708, 1976, 17 pp.

_____. Analyses of Natural Gases, 1917-74. BuMines Computer Printout, 1976, 889 pp.; NTIS PB 251 202/AS.

_____. Analyses of Natural Gases, 1975. BuMines IC 8717, 1976, 82 pp.

_____. Analyses of Natural Gases, 1976. BuMines IC 8749, 1977, 94 pp.

_____. Analyses of Natural Gases, 1977. BuMines IC 8780, 1978, 95 pp.

Moore, B. J. Helium Resources of the United States, 1977. BuMines IC 8803, 1979, 25 pp.

_____. Analyses of Natural Gases, 1978. BuMines IC 8810, 1979, 113 pp.

_____. Helium Resources of the United States, 1979. BuMines IC 8831, 1980, 27 pp.

_____. Analyses of Natural Gases, 1979. BuMines IC 8833, 1980, 100 pp.

_____. Analyses of Natural Gases, 1980. BuMines IC 8856, 1981, 236 pp.

_____. Analyses of Natural Gases, 1917-80. BuMines IC 8870, 1982, 1,055 pp.

Miller, R. D., and F. R. Hertweck, Jr. Analyses of Natural Gases, 1981. BuMines IC 8890, 1982, 84 pp.

Hertweck, F. R., Jr., and R. D. Miller. Helium Resources of the United States, 1981. BuMines IC 8927, 1983, 17 pp.

Miller, R. D., and F. R. Hertweck, Jr. Analyses of Natural Gases, 1982. BuMines IC 8942, 1983, 100 pp.

Hertweck, F. R., Jr., and D. D. Fox. Analyses of Natural Gases, 1983. BuMines IC 8993, 1984, 127 pp.

Miller, R. D. Helium Resources of the United States, 1983. BuMines IC 9028, 1985, 17 pp.

Moore, B. J., and J. E. Hamak. Analyses of Natural Gases, 1984. BuMines IC 9046, 1985, 102 pp.

APPENDIX.--GLOSSARY¹

Helium Resource--All helium contained in natural gases and helium that has been extracted from natural gases and is being stored for future use.

Helium Reserve--The portion of the identified helium resource that is in storage and the helium contained in the proved resources of gases containing at least 0.3% helium. These are the resources now being processed for helium or those most likely to be processed if helium demand is increased.

Helium in Storage--The helium stored by the Federal Government in Cliffside Field.

Identified Resource--A collective term for the helium in both measured and indicated resources.

Measured^{*}--Helium in gas reserves for which estimates have been made with a margin of error of less than 20%.

Measured resources are comparable to those reserves termed "proved" by the gas industry.

Indicated^{*}--Helium in gas resources associated with measured reserves for which estimates have been made by using reasonable engineering and geologic projections.

Indicated resources are comparable to those resources termed "probable" by the gas industry.

Undiscovered Resources--Unspecified deposits of helium surmised to exist on the basis of broad geologic knowledge and theory.

Hypothetical Resources^{*}--Undiscovered helium that may reasonably be expected to exist in a known gas-producing area under

known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as an identified resource.

Hypothetical resources are comparable to those resources termed "possible" by the gas industry.

Speculative Resources^{*}--Undiscovered helium deposits that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification.

Speculative resources are comparable to those resources also termed "speculative" by the gas industry.

Proved Natural Gas Reserves--The currently estimated quantity of natural gas that analysis of geologic and engineering data demonstrate with reasonable certainty to be recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions.

Potential Natural Gas Resources--Those natural gas resources called probable, possible, and speculative by the PGC, which are defined in the section "Helium in Potential Resources of Natural Gas" in this report.

Depleting Natural Gas Resource--A natural gas deposit that is being depleted by production for use as fuel or for other purposes.

Nondepleting Natural Gas Resource--A natural gas deposit that is not being produced because of the low heating value of the gas, lack of market, or some other reason.

¹Asterisk (*) beside a term indicates that there is a comparable gas industry term; these terms are explained at the end of the entry.

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